3.0 Validation Results, Functional Element Level

End-to-end model validation is generally inconclusive. That is, if overall modeled performance of a system correlates with measured system performance, the correlation may be coincidental or the model may indeed be valid for the conditions of test. In the case where modeled end-to-end performance does not correlate with measured system performance, the cause of invalid modeled system performance is uncertain.

To understand the causal relationships between apparent discrepancies (or coincidental matches) of modeled system performance and measured system performance, it is necessary to validate the performance of each modeled component that contributes to the system being simulated. The purpose, therefore, of functional element validation is to provide comparative analysis of modeled and measured functional performance in order to understand the impact of each function on overall model performance.

3.0.1 Summary of FE Assessment

Table 3.0-1 summarizes the results of FE validation conducted to date. Significant findings are discussed after the table.

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Table 3.0-1 Results of FE Validation Conducted to Date

FE Number	Functional Element	Test Cases
13	Multipath / Diffraction	2
20	Antenna Gain	1
23	MTI	1

Multipath/Diffraction: Results for test case 1, ATCOM/AATD SPAR model data, are inconclusive. Further testing is required to validate this FE. Such testing must include extremely accurate target altitude measurements in order to assess the ALARM implementation of multipath.

The second validation test, a comparison of measured and modeled one-way pattern-propagation factors, indicates significant differences, particularly as a function of the method chosen by ALARM to determine the one-way pattern-propagation factors. The overall impact of these differences on the prediction of maximum target detection is significant if a clear line-of-sight exists between the radar and the target. If the target is masked from the radar, the impact is insignificant.

Several Model Deficiency Reports (MDRs) were generated during testing that report known or suspected problems with the ALARM implementation of this FE. These MDRs are summarized in table 3.0-2; ALARM ASP I, Appendix C, contains a complete list of MDRs.

Table 3.0-2 Model Deficiency Reports of Multipath/Diffraction Errors

MDR	Date	Description	Disposition
9	9 Nov 92	Negative round earth diffraction factors	ALARM92
21	21 Oct 93	Incorrect SEKE antenna gain calculation	New
22	11 Jan 94	Incorrect clutter processing for coastal sites	New
24	26 Jan 94	Incorrect SEKE processing (per Lincoln Laboratory)	New
27	31 Jan 94	Add SEKE1 algorithm	New
33	2 Jun 94	Incorrect sea-state definitions in the analyst’s manual	New
34A	21 Sep 94	Incorrect SEKE diffraction affects threshold	New

Disposition:
ALARM 92 - Implemented in ALARM92 (ALARM 3.0 beta version).
New- Not yet reviewed by the ALARM Users Group and CCB

Implications of these errors for model users are discussed below.

1. All MDRs identified by a status indicating an implementation version have been fixed in the specified version.

2. Errors found during the SMART verification process are not listed here unless the developer (SAIC), in agreement with the independent verifying agent (ENTEK), has opened an MDR for the alleged anomaly.

3. MDRs 21, 24, 27, and 34A represent identified differences between the ALARM implementation of the Lincoln Laboratory (LL) SEKE propagation algorithms, and the LL version. On several occasions LL has briefed differences in the propagation factor generated in ALARM/SEKE vice that generated by their in-house SEKE code. To date, LL has specifically observed that the majority of these differences seem to be caused by the multipath calculations. Both LL and SAIC are committed to reviewing the SEKE code during FY95. Corrections to the ALARM implementation are anticipated pending the results of those investigations.

4. MDR 22, *Incorrect Clutter Processing for Coastal Sites*, will only cause problems in the modeling of radar performance of coastal sites where the target appears both over land and over water. This problem can be dealt with by

making two separate model runs with different propagation/clutter parameters, then manually merging the results. Code has been developed by SAIC to provide the data to the model to more accurately represent the problem, but it is not yet known whether the CCB will approve the proposed change.

5. MDR 33, *Change Sea State Definition in Documentation*, suggests clarification of the actual definitions of the sea states used in the model. There is no impact on the informed user.

Antenna Gain: Antenna gain can have a significant impact on detection range in a clutter environment. There are also some differences, although small, noted in the stand-off jamming environment. It is recommended that a 3-D measured antenna gain pattern, rather than a pattern built by ALARM from a 2-D pattern, be used in studies involving high clutter and/or stand-off jamming environments.

Four errors have been uncovered for the Antenna Gain FE as a result of the SMART Project V&V efforts. These are summarized in the table below; implications for model use are discussed after the table.

Table 3.0-3 Model Deficiency Reports of Antenna Gain Errors

MDR	Date	Description	Disposition
3	10 Jul 92	Gain for square apertures only considered by ALARM	ALARM92
19	15 Mar 93	Incorrect interpolation of transmit and receive antenna gain	ALARM92
63	26 Apr 95	Slight differences in calculation of transmit and receive antenna gain	New
65	2 May 95	In some cases, ALARM is not detecting when the transmit and receive antenna gain patterns differ	New

Disposition:
ALARM 92 - Implemented in ALARM92 (ALARM 3.0 beta version).
New- Not yet reviewed by the ALARM Users Group and CCB

1. MDR 3, *ALARM Calculates Gain for Square Apertures Only*, was corrected in ALARM 92. This error could cause incorrect estimates of clutter and jamming signals when modeling radar antennae having other than square apertures.

2. MDR 19, *Incorrect Interpolation of Transmit and Receive Antenna Gain*, was also corrected in ALARM 92. This error could lead to erroneous model results.

3. MDR 63, *Differences in Subroutines TGAIN and RGAIN*, points out a slight discrepancy in the way transmit and receive antenna gain are calculated. This

can lead to small differences between the transmit and receive gain for the same antenna pattern.

4. MDR 65, *ALARM Not Always Detecting When Transmit and Receive Antenna Gain Patterns Differ*, prevents the user from specifying different transmit and receive antenna gain patterns in in-line mode.

MTI: One validation test for this functional element is included in this document. The comparison of measured MTI response relative to the ALARM modeled MTI response indicates significant differences in the gain/attenuation at target blind speeds which occur when the relative velocity of the target creates doppler frequencies that are integer multiples of the radar PRF. However, the overall impact of these differences on the prediction of maximum target detection is insignificant.

One error has been uncovered in the ALARM implementation of MTI, documented in MDR 1. The problem, fixed in ALARM 92, concerned invalid algorithms for staggered-pair MTI. It caused ALARM to incorrectly estimate both clutter and target signal power.

3.0.2 FE Validation Methodology

The general method employed in the validation of functional elements consists of correlating data generated during field testing with data produced by ALARM under conditions that match those of the field tests as closely as possible. The procedures used to correlate the data vary from one FE to another, but generally consist of comparisons of graphs of measured vs. modeled data and statistical analysis of differences between the two sets of data.

The results of validation testing for each FE are presented in the remainder of section 3 in this format:

1. FE Description: General theory about the function within the context of real-world radar systems, and a brief description of its implementation in ALARM.

2. Validation Objective: Objective of the FE validation test, including measures of effectiveness.

3. Field Test Description: Brief description of the field test that generated the data used to validate the ALARM FE.

4. Data Description: Data collected during the field test.

5. Data Processing: Any special processing of the field test data required before it could be used for validation testing.

6. Analysis Procedures: Procedures followed to generate ALARM data and correlate this data with field test values.

7. Results and Interpretation: Discussion of results of correlation analysis.

8. Conclusions: Assessment of ALARM implementation of the FE, including any discovered problems, errors, or anomalies, and their impact on credible model use.

Data from more than one field test is available for some FEs. In these cases, numbers 2. through 8. described above are repeated for each field test.